U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: CERTIFICATION OF TRANSPORT CATEGORY AIRPLANES FOR FLIGHT IN ICING CONDITIONS

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Change:

1. PURPOSE. This advisory circular (AC) provides guidance for certification of airframe ice protection systems on transport category airplanes. While this is the primary focus of this AC, the guidance also supplements similar guidance provided in other AC's concerning icing requirements for other parts of the airplane.

2. APPLICABILITY.

a. The guidance provided in this document is directed to airplane manufacturers, modifiers, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport airplane type certification engineers and their designees.

b. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. The FAA will consider other methods of demonstrating compliance that an applicant may elect to present. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. On the other hand, if we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation or design changes as a basis for finding compliance.

c. This material does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

3. CANCELLATION. Advisory Circular 25.1419-1, dated 8/18/99, is canceled.

4. ICING REQUIREMENTS. The guidance provided herein applies to the approval of the installation and operation of ice protection systems in the icing environment defined in 14 CFR part 25, Appendix C. If certification for flight in icing conditions is desired, the airplane must be able to safely operate throughout the icing envelope of Appendix C. Section 25.1419 sets forth the specific airframe requirements for demonstrating compliance with the icing conditions defined in Appendix C. Additionally, for other parts of the airplane (i.e., engine, engine inlet, propeller) there are more specific icing requirements and associated guidance defined in the

referenced regulations and advisory circulars listed in paragraph 3 below. Some of the icing-related regulations must be complied with, even if the airplane is not certificated for flight in icing (e.g., §§ 25.629(d)(3), 25.903, 25.975, 25.1093, 25.1323(e), and 25.1325(b)). This AC contains limited information on flight tests for icing certification; additional information may be found in Advisory Circular 25-7A, referenced in paragraph 3 of this AC. The guidance provided in this AC is applicable to new Type Certificates (TC's), Supplemental Type Certificates (STC's), and amendments to existing TC's for airplanes certified under Part 4b of the Civil Aviation Regulations (CAR) and Part 25, for which approval under the provisions of § 25.1419 is desired.

5. RELATED REGULATIONS AND DOCUMENTS.

a. Regulations.

§ 25.629	-	Aeroelastic stability requirements
§ 25.773(b)(1)(ii)	-	Pilot compartment view
§ 25.903	-	Engines
§ 25.929	-	Propeller deicing
§ 25.975	-	Fuel tank vents and carburetor vapor vents
§ 25.1093	-	Induction system icing protection
§ 25.1323(e)	-	Airspeed indicating system
§ 25.1325(b)	-	Static pressure systems
§ 25.1326	-	Pitot heat indication system
§ 25.1403	-	Wing icing detection lights
§ 25.1585(a)(6)	-	Operating procedures
§ 33.68	-	Induction system icing
§ 33.77	-	Foreign object ingestion
§ 33.78	-	Rain and hail ingestion

b. Advisory Circulars. The AC's listed below may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, M-30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20795:

AC 20-73	Aircraft Ice Protection, dated 4/21/71.
AC 25-7A	Flight Test Guide for Certification of Transport Category Airplanes, dated 3/31/98.
AC 25-11	Transport Category Airplane Electronic Display Systems, dated July 16, 1987
AC 25.629-1A	Flutter Substantiation of Transport Category Airplanes, dated 7/23/98.

AC 25.1309-1A	System Design Analysis, dated 6/21/88.
AC 20-117A	Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing, dated 12/17/82.
AC 20-115B	Radio Technical Commission for Aeronautics, Inc. (RTCA) Document RTCA/DO-178B, dated 1/11/93.
AC 120-42A	Extended Range Operation with Two-Engine Airplanes (ETOPS), dated 12/30/88

Note: AC 25-7A is available from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402 (stock number 050-007-01214-4; $33.00).

6. RELATED READING MATERIAL.

a. RTCA/DO-178B, “Software Considerations in Airborne Systems and Equipment Certification,” published December 1, 1992, provides an acceptable means of compliance for software used in airborne systems and equipment. This document may be obtained from the RTCA Inc., 1140 Connecticut Avenue NW., Suite 1020, Washington, D.C. 20036.

b. FAA Technical Report DOT/FAA/CT-88/8-1, "Aircraft Icing Handbook" published March 1991, updated September 1993, includes reference material on ground and airborne icing facilities, simulation procedures, and analytical techniques. This document represents all types and classes of aircraft and is intended as a working tool for the designer and analyst of ice protection systems.

c. FAA Technical Report ADS-4, “Engineering Summary of Airframe Icing Technical Data,” and Report No. FAA-RD-77-76, “Engineering Summary of Powerplant Icing Technical Data,” provide technical information on airframe and engine icing conditions, and methods of detecting, preventing, and removing ice accretion on airframes and engines in flight. Although most of the information contained in ADS-4 and FAA-RD-77-76 is still valid, some is outdated. More usable information is now available through recent research and experience and is included in the Aircraft Icing Handbook referenced in paragraph b. above.

Note: The FAA technical reports listed above can be obtained from the National Technical Information Service (NTIS), Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

d. RTCA/DO160D, “Environmental Conditions and Test Procedures for Airborne Equipment.” This document may be obtained from the RTCA Inc., 1140 Connecticut Avenue NW., Suite 1020, Washington, D.C. 20036.

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1. BACKGROUND.

a. Civil Air Regulations (CAR).

(1) Prior to 1953, airplanes were certificated under Part 04 of the CAR. Section 04.5814 required that if deicer boots were installed, then positive means must be provided for the deflation of all wing boots. There were no other references to an airplane ice protection system in Part 04.

(2) Part 4b of the CAR was codified on December 31, 1953. The requirement for positive means of deflating deicer boots was incorporated, without change, in § 4b.640. Section 4b.640 stated that, "When an ice protection system is installed, it shall be of an approved type. If pneumatic boots are used, at least two independent sources of power and a positive means for the deflation of the boots shall be provided." Section 4b.351(b)(ii) provided requirements for pilot compartment vision in icing conditions. Section 4b.406 provided propeller-deicing requirements. Section 4b.461 provided induction system deicing and anti-icing requirements. Section 4b.612(a)(5) required that the airspeed indicating system be provided with a heated pitot tube or equivalent means of preventing malfunctioning due to icing.

(3) Amendment 4b-2, effective August 25, 1955, introduced icing envelopes similar to the current Appendix C to part 25. The graphs added by Amendment 4b-2 (4b-24a, 4b-24b, 4b-24c, 4b-25a, 4b-25b, and 4b-25c) were identical in substance and format to the current Appendix C envelopes with a few exceptions. These envelopes described the liquid water content, the mean effective diameter of droplets, the temperature, and horizontal and vertical extent of the supercooled icing cloud environment. In the figures introduced by Amendment 4b-2, the units of the distances shown on the graphs were expressed in statute miles instead of nautical miles. The Liquid Water Content (LWC), however, is identical between the Amendment 4b-2 figures and the current Appendix C envelopes, if the correction for the difference in value between nautical and statute miles is made. There are two significant differences between the Amendment 4b-2 envelopes and the current Appendix C. The minimum mean effective diameter in the intermittent maximum conditions was 20 microns versus the current 15 microns, and the LWC/distance factor was 1.5 statute miles versus the current 0.26 nautical miles (0.3 statute miles).

(4) Amendment 4b-6, effective August 12, 1957, revised the icing envelopes to the current requirements and revised § 4b.461, "Induction system de-icing and anti-icing provisions." The preamble to the amendment states, "There are included herein changes which extend the currently effective provisions governing intermittent maximum icing conditions so as to cover conditions which might be critical insofar as the turbine engine induction system is concerned. In this regard, the data are being extended in accordance with NACA Technical Note 2738 and involve a revision of Figure 4b-25a to cover drop diameters as small as 15 microns and a revision of Figure 4b-25c to cover distances down to 0.3 mile. The icing conditions prescribed in the currently effective regulations are applicable in the main to the airframe. The changes

being made in section 4b.461 require the turbine powerplant to be subjected to the same icing conditions and require that the induction system be protected to prevent serious engine power loss. A similar requirement is incorporated with respect to certification of turbine engines by an amendment to Part 13 which is being made concurrently with this amendment."

b. Part 25.

(1) Part 4b of the CAR was recodified into part 25, effective February 1, 1965. After recodification, with minor editorial changes the content of § 4b.640, Ice protection, became § 25.1419; § 4b.406, Propeller deicing provisions, became § 25.929; § 4b.612(a)(5), Airspeed indicating systems, became § 25.1323(e); § 4b.351(b)(1)(ii), Pilot compartment view, became § 25.773(b)(1)(ii). The § 4b.351 reference to the most severe icing conditions for which approval of the airplane is desired was changed in part 25 to reference the icing conditions specified in § 25.1419. Section 4b.461, Induction system deicing and anti-icing provisions, became § 25.1093.

(2) Amendment 25-5, effective July 29, 1965, revised § 25.1325(b) to require that the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not changed when the airplane is exposed to the continuous and intermittent maximum icing conditions defined in Appendix C.

(3) Amendment 25-11, effective June 4, 1967, revised § 25.1585 to require that the Airplane Flight Manual include information on the use of ice protection equipment.

(4) Amendment 25-23, effective May 8, 1970, revised § 25.1419 to require that the effectiveness of the ice protection system and its components be shown by flight tests of the airplane or its components in measured natural atmospheric icing conditions. Previous to this amendment, flight tests in natural icing conditions were considered as one means of compliance but were not mandatory. Amendment 25-23 also revised § 25.1309 to include additional requirements for certificating equipment, systems, and installations. The regulation was revised to require a comprehensive systematic failure analysis, supported by appropriate test, to ensure that the safety objectives of the probability of occurrence decrease as the hazard of a failure increases.

(5) Amendment 25-38, effective February 1, 1977, added § 25.1403 to require a means for illuminating or otherwise determining the formation of ice on the parts of the wings that are critical from the standpoint of ice accumulation. The requirement is not applicable if the operating limitations prohibit operations at night in known or forecast icing conditions.

(6) Amendment 25-43, effective April 12, 1978, added § 25.1326 to require the installation of a pitot heat indication system on airplanes equipped with flight instrument pitot heating systems.

(7) Amendment 25-46, effective December 1, 1978, added § 25.1416 to require specific standards for pneumatic deicer boots.

(8) Amendment 25-72, effective July 20, 1990, transferred § 25.1416 to § 25.1419 for clarification and editorial improvement. In addition, the contents of § 25.1416(c), which required a means to indicate to the flightcrew that the pneumatic deicing boot system is receiving adequate pressure and is functioning normally, were revised to allow the use of the "dark cockpit" concept (i.e., a warning when failure occurs rather than continual pilot monitoring of a healthy system).

2. CERTIFICATION PLAN. At the start of the design and development effort, the applicant should submit a certification plan to the cognizant FAA Aircraft Certification Office (ACO) for approval. The certification plan should include the following basic information:

a. A general airplane description that includes dimensions, airworthiness limitations, and other data that may be relevant to certification of ice protection systems.

b. Ice protection systems description.

c. A compliance checklist that addresses each section of part 25 applicable to the product.

d. Identification of the certification methods for each applicable section of part 25, including a description of analyses and tests, or references to similarity of designs, that the applicant intends for certification of the ice protection system. These methods of showing compliance should be agreed upon between the applicant and the FAA early in the certification program prior to conducting certification tests.

e. A failure hazard assessment to determine the criticality of the system.

f. If the ice protection or detection systems contain software, software plans, as described in RTCA DO-178B (or another acceptable means of compliance for software).

g. Projected schedules of design, analyses, testing, and reporting.

h. A list of any anomalous 14 CFR part 33 icing certification test results, if completed, that will require special operating procedures.

i. If the ice protection or detection systems contain complex electronic hardware (such as programmable logic devices (PLD) or application specific integrated circuits (ASIC)), plans for providing a level of design assurance of these devices commensurate with their potential contribution to aircraft hazards and system failures, which could result from electronic hardware faults or malfunctions.

3. ANALYSES. The applicant should prepare analyses to substantiate decisions involving the application of selected ice protection equipment. Such analyses should clearly state the basic protection required and the assumptions made, and delineate the methods of analysis used. All analyses should be validated either by tests or have been validated by the applicant on previous programs. This substantiation should include a discussion and rationale of the assumptions made in the analyses. To utilize a previously validated methodology, the applicant should substantiate that the methodology is applicable to the new program. The following is a list of analyses typically performed during an icing certification program:

a. Analysis of Areas and Components to be Protected. The applicant should examine those areas listed below to determine the degree of protection required:

(1) Leading edges of wings, winglets, and wing struts; horizontal and vertical stabilizer; canards; and other lifting surfaces.

(2) Leading edges of control surface balance areas, if not shielded.

(3) Accessory cooling air intakes that face the airstream and/or could otherwise become restricted due to ice accretion.

(4) Antennas and masts.

(5) External tanks.

(6) External hinges, tracks, door handles, and entry steps.

(7) Instruments including pitot tube (and mast), static and dynamic ports, angle-of-attack sensor, and stall warning.

(8)) Forward fuselage nose cone and radome.

(9) Windshields.

(10) Landing gear.

(11) Retractable forward landing lights.

(12) Ram air turbines.

(13) Ice detection lights, if required for compliance with § 25.1403.

(14) Vortex generators installed on lifting surfaces and the fuselage, and stall improvement devices such as strips, vortilons, and fences.

(15) Any structure that extends into the free stream such as cameras, camera mounts, and video equipment.

Note 1: Ice protection of fuel tank vents, propellers, and engine inlet cowls is addressed by part 25, subpart E – Powerplant.

Note 2: An applicant may determine that protection is not required for one or more of these areas or components. If so, the applicant should include supporting data and rationale in the analyses for allowing those areas or components to go unprotected. The applicant should show that the lack of protection does not adversely affect the handling characteristics or performance of the airplane. Section 25.1419(b) of part 25 at amendment level 25-72 requires certain flight testing. However, flight test data from previous certification programs may be used as an integral part of a complete data package used for establishing compliance with 25.1419(b) if it can be shown that the flight test data is applicable to the airplane in question. This would generally require a similarity analysis. If a similarity analysis is used, the guidelines of paragraph 3(f) of this AC are applicable. If there is uncertainty about the effects of the lack of protection, or the similarity analysis, the manufacturer should conduct flight test demonstrations.

b. The 45-Minute Hold Condition. Ice shapes resulting from a 45-minute hold condition should be considered when developing critical ice shapes for which the overall performance and handling characteristics of the airplane are to be analyzed. The airplane's tolerance to continuous ice accumulation on the unprotected surfaces should be evaluated in accordance with the information provided in AC 20-73. The applicant should determine the effect of the 45-minute hold in continuous maximum icing conditions. It should be assumed that the airplane will remain in a rectangular “race track” pattern, with all turns being made within the icing cloud. Therefore no horizontal extent correction should be used for this analysis. The applicant should substantiate the critical mean effective drop diameter, LWC, and temperature that result in the formation of an ice shape that is critical to the airplane’s performance and handling qualities. The critical ice shapes derived from this 45-minute hold analysis should be compared to critical shapes derived from other analyses (i.e., for climb, cruise, and descent) to establish the most critical artificial ice shapes to be used during dry air flight tests. Not only is the thickness important, but the shape, location, and texture may contribute to adverse aerodynamic characteristics.

Note: The 45-minute hold condition will result in large ice shapes on the unprotected surfaces that, from visual assessment alone, would appear to have a drastic effect on airplane performance and handling characteristics. Operational history and wind tunnel tests have shown that the ice that forms on the protected and unprotected surfaces before activation and normal operation of the ice protection system may also have a detrimental effect on the lift and pitching moment characteristics of the wing and horizontal tail airfoils. Similarly, for airplanes with cyclic ice protection systems, the ice that accretes on the protected surfaces between cycles may have more than an insignificant contribution to the total effect of ice on the airplane performance and handling characteristics, when combined with the 45-minute holding ice accretion on the unprotected surfaces.

c. Flutter Analysis. Advisory Circular (AC) 25.629-1A, "Flutter Substantiation of Transport Category Airplanes," provides guidance for showing compliance with § 25.629. Section 25.629(d)(3) requires the consideration of inadvertent encounters with icing for airplanes not certificated for flight in icing conditions.

d. Power Sources. The applicant should evaluate the power sources in the ice protection system design (e.g., electrical, bleed air, and pneumatic sources). An electrical load analysis or test should be conducted on each power source to determine that it is adequate to supply the ice protection system plus all other essential electrical loads throughout the airplane flight envelope under conditions requiring operation of the ice protection system. The effect of an ice protection system component failure on power availability to other essential loads should be evaluated in accordance with § 25.1309. All power sources that affect engine or engine ice protection systems for multiengine airplanes must comply with the engine isolation requirements of § 25.903(b).

e. Failure Analysis. Advisory Circular (AC) 25.1309-1A, "System Design Analysis," provides guidance for demonstrating compliance with the requirements of § 25.1309. Substantiation of the hazard classification of ice protection system failure conditions is typically accomplished through analyses and/or testing. The failure analysis should include the potential contribution of complex electronic hardware faults and malfunctions to system failure conditions, and classify the hardware assurance level appropriately.

f. Similarity Analyses.

(1) In the case of certification based on similarities to other type certificated airplanes previously approved for flight in icing conditions, the applicant should specify the airplane model and the component to which the reference applies. Specific similarities should be shown in the areas of physical, functional, thermodynamic, pneumatic, aerodynamic, and environmental exposure. Analyses should be conducted to show that the component installation, operation, and the effect on the airplane's performance and handling are equivalent to that of the previously approved configuration.

(2) Similarity requires an evaluation of both the system and installation differences that may adversely affect the system performance. An assessment of a new installation should consider differences affecting the airplane and the system. If there is uncertainty about the effects of the differences, additional tests and/or analyses should be conducted as necessary and appropriate to resolve the open issues.

(3) Engineering judgment should be used to determine if the ice protection system should be retested in measured natural icing conditions. The differences in the ice protection systems should be evaluated for their effect on the functionality of the ice protection systems and on safe flight in icing. If there is uncertainty about the effects of the differences, flight tests in measured natural icing conditions should be accomplished.

Note: The applicant must possess all the data to substantiate compliance with applicable regulations, including the data from past certifications on which the similarity analysis is based.

g. Impingement Limit Analyses. The applicant should prepare a droplet trajectory and impingement analysis of the wing, horizontal and vertical stabilizers, propellers, and any other surfaces that may require icing protection. This analysis should consider the various airplane operational configurations and the associated angles of attack. The analysis should establish the upper and lower aft droplet impingement limits that can then be used to establish the aft ice formation limit and the ice protection coverage needed.

4. DRY AIR GROUND TESTS. Depending upon the details of the ice protection system design details, some preliminary ground tests of the equipment may be warranted to verify the basic function of each item. Quantitative data may be obtained, as necessary, to verify the system designs. These data include operating temperatures of thermal devices, deicing fluid flow rates and flow patterns for deicing liquid devices, and operating pressures and rates of inflation of pneumatic components.

5. FLIGHT TEST PLANNING. When operating any airplane in an icing environment, degradation in performance and flying qualities may be expected. The primary purposes for flight testing an airplane equipped for flight in icing conditions is to evaluate such degradation, and to determine that the flying qualities remain adequate and that performance levels are acceptable for this flight environment.

In accordance with part 33, engine icing certification results should also be carefully reviewed prior to any part 25 engine or airframe icing flight tests in order to determine if there were any anomalous results that will require special airplane/engine operating procedures. The flight tests and analyses of flight tests should:

a. Demonstrate normal operation of the airplane with the ice protection system installed in non-icing flight.

b. Demonstrate the ability of the airplane to operate safely with critical in-flight ice shapes. The icing conditions specified in part 25, Appendix C, are used to determine these ice shapes.

c. Verify the analytical predictions that the ice protection system will perform its intended function throughout the icing envelope defined in Appendix C.

d. Verify the adequacy of the flightcrew procedures and limitations for the use of the ice protection system in normal, abnormal, and emergency conditions.

e. Demonstrate operation of the airplane in icing conditions with failed ice protection systems, which may include asymmetric icing.

f. Confirm that the powerplant installation as a whole (engine, inlet, anti-ice system, etc.) performs satisfactorily while in icing conditions. In addition, the APU should be evaluated for performance in icing conditions if it performs essential functions.

6. COMPLIANCE TESTS (Flight/Simulation). The following paragraphs address the major flight tests normally performed to show compliance with the requirement of § 25.1419 that the airplane must be able to safely operate in the continuous maximum and intermittent maximum icing conditions described in Appendix C to part 25. The airplane should be shown to comply with the certification requirements when all ice protection systems are installed and functioning. This can normally be accomplished by performing tests at those conditions found to be most critical to basic airplane aerodynamics, ice protection system design, and powerplant functions. All anti-ice and deice equipment should perform its intended function throughout the entire operating envelope.

a. Three Typical Stages of Icing Flight Tests:

(1) Dry air flight tests with ice protection equipment operating;

(2) Dry air flight tests with predicted artificial ice shapes installed; and

(3) Natural icing flight tests.

b. Dry Air Flight Tests with Ice Protection Equipment Operating. Initial dry air flight tests are usually the first steps conducted to evaluate the airplane with the ice protection system operating. The initial dry air tests are conducted to verify that the ice protection system does not affect the flying qualities of the airplane in clear air and to obtain a thermal profile of an operating thermal ice protection system. Several commonly used ice protection systems and components are discussed below to illustrate typical dry air flight test practices. Other types of equipment should be evaluated as their specific design dictates.

(1) Hot Air Thermal Anti-ice (TAI) Leading Edge Systems. Dry air flight tests are conducted to verify the system design parameters and thermal performance analyses.

(a) Normally, the system components are instrumented to measure the anti-icing mass flow rate, supply air temperature, and the surface temperatures. The dry air test plan generally includes the airplane operating conditions such as climb, holding, and descent phases of a normal flight profile. Since the presence of moisture can affect the surface temperatures, the tests should be conducted where the humidity is low.

(b) The measurements of anti-icing mass flow rate and supply air temperature allow the determination of heat available to the system. The adequacy of the ice protection system then can be demonstrated through a comparison of the measured data to the theoretical analysis over the entire Appendix C icing envelope. The surface temperatures measured in the dry air, for example, can be useful in extrapolating the maximum possible leading edge surface temperature in-flight, the heat transfer characteristics of the system, and the thermal energy available for the ice protection system. The supply air temperatures also may be used to verify that the materials of the ice protection system were appropriately chosen for the thermal environment.

(2) Hot Air Thermal Deice Leading Edge Systems. Normally the TAI system is designed and certified as an anti-icing system. Some airplane manufacturers may recommend that the system be operated as a deice system. The leading edge of the airplane airfoils are deiced once the pilot has detected icing through a visual cue or the deicing is initiated either automatically or manually after an ice detection system has sensed the presence of ice. The same type of testing described in paragraph (1) above should be considered for this type of system.

(3) Pneumatic Leading Edge Boots. Tests should demonstrate a rise and decrease in operating pressures, which results in the effective removal of ice. This pressure rise time, as well as the maximum operating pressure for each boot, should be evaluated throughout the altitude band defined in Appendix C (i.e., mean sea level (MSL) to 22,000 feet above MSL). Boots should be operated in flight at the minimum envelope temperature (-22 ^{o}F) of Appendix C, to demonstrate adequate performance throughout the entire flight envelope and to demonstrate that no damage occurs during inflation and deflation. The appropriate speed and temperature limitation (if any) on boot activation should be included in the Airplane Flight Manual (AFM). The inflation of the boots should have no hazardous effect on airplane performance and handling qualities.

(4) Electrically Heated Propeller Boots. For compliance with the provisions of §§ 25.901(c), 25.903(b), 25.929, and 25.1419(c):

(a) When flight testing in dry air, the following system parameters should be monitored to confirm proper function. It is suggested that system current, brush block voltage (i.e., between each input brush and the ground brush) and system duty-cycles be monitored to ensure that adequate power is applied to the deicers. Surface temperature measurements should be made during dry air tests. These surface temperature measurements are useful for correlating analytically predicted dry air temperatures with actual temperatures, and as a general indicator that the system is functioning and that each deicer is heating.

(b) The system operation should be checked throughout the full r.p.m. and propeller cyclic pitch range expected during flight in icing. Any significant vibrations should be investigated.

(c) Consideration should be given to the maximum temperatures that a composite propeller blade may be subjected to when the deicers are energized. It may be useful to monitor deicer bond-side temperatures. When performing this evaluation, the most critical conditions should be investigated (e.g., airplane on the ground; propellers non-rotating) on a hot day with the system inadvertently energized.

(5) Windshield Anti-Ice. Section 25.773(b)(ii) requires that the airplane must have a means to maintain a clear portion of the windshield in icing conditions specified in § 25.1419, if certification with ice protection provisions is requested. Dry air flight tests should be conducted to verify the thermal analysis. Both inner and outer windshield surface temperature measurements of the protected area may be needed to verify the thermal analysis. Thermal analysis should substantiate that the windshield surface temperature is sufficient to maintain anti-icing capability without causing structural damage to the windshield. An evaluation of the visibility, including distortion effects through the protected area, should be made for both day and night operations. In addition, the size and location of the protected area should be reviewed for adequate visibility, especially during the approach and landing phases of flight.

(6) Pitot-Static and Static Pressure Sources. Section 25.1323(e) requires a heated pitot tube or an equivalent means of preventing malfunction due to icing for each airspeed indicating system; § 25.1325(b) requires that static pressure ports be designed and located such that the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not affected when the airplane encounters icing conditions defined in Appendix C; and § 25.1326 requires an indication system be provided to indicate to the flightcrew when a pitot heating system is not operating. An acceptable indication system may consist of separate lights or crew alert indication on an electronic display for each pitot source. Additional guidance on an acceptable means of compliance with § 25.1326 is provided in AC 25-11. Component surface temperature evaluations should be performed to verify thermal analyses.

(7) Compressor Bleed Air Systems. The effects of any bleed air extraction on engine and airplane performance should be examined and included in the AFM performance data. The surface heat distribution analysis should be verified for varying flight conditions including climb, cruise, hold, and descent. Temperature measurements may be necessary to verify the thermal analyses. In accordance with the provisions of § 25.939(a), the effects of the maximum bleed air for ice protection should have no detrimental effect on engine operation throughout the engine's power range.

c. Dry Air Flight Tests with Predicted Artificial Ice Shapes. The installation of artificial ice shapes on the test airplane allows airplane performance and handling characteristics to be evaluated in stable dry air conditions with the critical ice shape remaining a constant (i.e., no change of ice accretion due to erosion, shedding, sublimation, etc., as can occur with natural ice shapes). Dry air flight tests with artificial ice shapes installed also result in a considerable reduction in the amount of flight testing that would otherwise be required to accumulate the test ice shapes in natural icing conditions and then evaluate their effects on airplane performance and handling characteristics in stable air.

(1) The shape and texture of artificial ice shapes should be developed and substantiated using methods found acceptable to the FAA. Common practices include: use of computer codes for droplet impingement limits and ice shape predictions, flight in measured natural icing conditions, icing wind tunnel tests, and flight in a measured controlled simulated icing cloud (e.g., behind an icing tanker). These methods should be conservative and should address the

conditions associated with the icing envelope of part 25, Appendix C, that are critical to the airplane's performance and handling qualities. It is not intended that natural icing flight tests validate all aspects of predicted ice shapes. Flight testing should be conducted in measured natural icing conditions (within the part 25, Appendix C icing envelope) to corroborate the general physical characteristics and location of the artificial ice shapes, and, in particular, their effect on airplane handling characteristics.

Note: The 45-minute hold condition will result in large ice shapes on the unprotected surfaces that, from visual assessment alone, would appear to have a drastic effect on airplane performance and handling characteristics. Operational history and wind tunnel tests have shown that the ice that forms on the protected and unprotected surfaces before activation and normal operation of the ice protection system may also have a detrimental effect on the lift and pitching moment characteristics of the wing and horizontal tail airfoils. Similarly, for airplanes with cyclic ice protection systems, the ice that accretes on the protected surfaces between cycles may have more than an insignificant contribution to the total effect of ice on the airplane performance and handling characteristics, when combined with the 45-minute holding ice accretion on the unprotected surfaces.

(2) The effects of the ice shapes on stall speeds and airplane climb performance should be determined. Stall warning margins and maneuvering capability should also be evaluated. Operating speeds, stall warning speeds, and AFM performance information should be adjusted, if necessary, to provide adequate performance capability and stall warning margins. The determination of the effects of ice on airplane performance should include the decrease of engine power or thrust resulting from the applicable operating mode of the ice protection system. In general, the effects on any system that utilizes bleed air should be determined. This information should appear in the AFM.

(3) Handling characteristics should be investigated to determine that an acceptable level of safety exists. The results of these tests may be used in preparing specific AFM operating procedures and limitations for flight in icing conditions.

(4) The effects on pitot-static, pressure sources, stall warning, and angle-of-attack sensors may need to be confirmed by dry air testing with shapes installed at critical locations that are not protected from ice accumulation. It should be confirmed that any ice formed on the airframe in the vicinity of the sensors does not adversely affect the sensor’s operation.

Note: Effects on the sensors are typically evaluated in natural icing conditions.

(5) Testing with ice shapes should be approached with extreme caution. A suitable buildup program to the full span ice shape configuration should be considered if sufficient analysis or similarity to other designs does not provide full confidence in the performance and handling qualities of the airplane with full-span ice shapes installed.

d. Icing Flight Tests. Flight tests in measured natural icing and the use of simulated icing tools, such as icing tankers and icing wind tunnels, are normally employed to demonstrate that the ice protection system performs during flight as predicted by analysis or other testing. They are also used to confirm the analyses used in developing the various components (e.g. ice detectors) and ice shapes and, in the case of natural icing tests, to confirm the conclusions reached during flight tests conducted with artificial ice shapes. Testing should be accomplished within the icing envelope of part 25, Appendix C, to verify the analytically predicted location and general physical characteristics of the ice accretions and, in particular, to corroborate the general nature of the effects on airplane handling characteristics and performance determined with artificial ice shapes.

(1) Instrumentation. Sufficient instrumentation should be planned to allow documentation of important airplane, system and component parameters, and icing conditions encountered. The following parameters should be considered:

(a) Altitude, airspeed, and engine power level or speed, as well as propeller speed and pitch (if applicable).

(b) Static air, engine component, electrical generation equipment, surface, interlaminate, and any other key temperatures that could be affected by ice protection equipment, by ice accumulation, or are necessary for validation of analyses.

(c) Liquid water content can be measured using a hot-wire anemometer-based instrument or other equivalent means.

(d) Median volume droplet diameter. This can be approximately determined by using a drop slide device. A gelatin oil or soot slide is exposed to supercooled liquid water and the resultant impact craters are measured with a microscope. Median volume diameter may also be measured using more sophisticated equipment such as a laser-based droplet measuring and recording instrument. Trained personnel should confirm that the equipment is properly calibrated and functioning during the tests.

(e) A means to measure ice accumulation, such as a rod mounted on the airfoil and the use of black paint on the airfoil.

(2) Simulated Icing.

(a) Testing in simulated icing environments, such as icing tunnels or behind icing tankers, represents one way to predict ice protection capabilities of individual elements of the ice protection equipment. Due to limited volume of the simulated icing environment, testing is usually limited to components having small exposed surfaces, such as heated pitot tubes, antennas, air inlets including engine induction air inlets, empennage, and other surfaces having small leading edge radii and windshields.

(b) A simulated icing exposure may be obtained by using onboard spray nozzles forward of the component under examination or by flying the test airplane in the cloud generated by an icing tanker. It may be difficult to obtain small droplet sizes with some spray nozzles; therefore, these methods could produce larger ice build-ups and different ice shapes than those observed in natural icing conditions within the icing envelope of part 25, Appendix C. Simulated icing tests should be evaluated to ensure the conditions of concern are accurately simulated.

(3) Natural Icing. Flight tests in measured natural icing conditions are required by § 25.1419 to verify the ice protection analysis, to check for icing anomalies, and to demonstrate that the ice protection system and its components function as intended. Advisory Circular 20-73 (paragraph 25) provides additional information that is useful for planning a natural icing flight test program. At least one exposure to icing conditions within the part 25, Appendix C, continuous maximum icing envelope should be obtained. The exposure should be sufficiently stabilized to obtain valid data. It is often difficult to obtain temperature stabilization during brief exposures. Additional exposures may be required to allow extrapolation to the envelope critical conditions by analysis. Test data obtained during these exposures may be used to validate the analytical methods used and the results of any preceding simulated icing tests.

(a) Past experience indicates that flight testing in natural intermittent maximum icing conditions may be accompanied by severe turbulence and possible hail encounters that could extensively damage the test airplane. When design analyses show that the critical ice protection design points (i.e., heat loads, critical ice shapes, accumulation, and accumulation rates, etc.) are adequate under these conditions, and sufficient ground or flight test data exist to verify the analysis, the flight test in intermittent maximum icing conditions may not be necessary.

(b) During natural icing flight tests, ice accumulation on unprotected areas should be observed, where possible, and sufficient data taken to allow correlation with dry air tests using artificial ice shapes. Remotely located cameras either on the test airplane or on a chase airplane have been used to document ice accumulations on areas that cannot be seen from the test airplane's flightdeck or cabin. A limited test program should be conducted in natural icing conditions to show a general correlation with the results of flight tests conducted with artificial ice shapes in dry air. In addition, flying qualities and performance should be qualitatively evaluated with the ice accumulations existing just prior to operation of deice (as opposed to anti-ice) components. The ice protection systems are to be activated by the flightcrew when icing conditions exist in accordance with AFM procedures proposed by the applicant. However, for anti-ice components, tests should also be conducted that simulate inadvertent icing encounters in which the pilot may not recognize that the airplane has entered an icing condition and the anti-ice component may not be activated until actual ice build-up is noticed. A delay in the activation of the ice protection system should be used in these tests to represent the flightcrew's failure to recognize that they are in icing conditions. The delay should be based on the icing recognition means available to the flightcrew for the particular airplane (e.g., visual observation of ice accumulations or an ice detector) and the recommended crew procedures. An ice accretion should be determined that would accumulate in the continuous maximum icing conditions of part 25, Appendix C, during the time period that represents the recognition delay, plus the time it takes for the ice protection system to perform its intended function. Handling qualities should remain acceptable to the test pilot, and the airplane should be capable of operating safely with this ice accretion.

(c) To use a thermal deice system as the ice protection system, the applicant may be required to demonstrate the effectiveness of the deice operation either in simulated icing conditions or during the natural icing flight test certification program. The tests usually encompass the measurements of the surface temperature time history. This time history includes the time the system is activated, the time the surface reaches an effective temperature, and the time the majority of ice is shed from the leading edge. It should be demonstrated that the effect of ice accretions resulting from any delay between the onset of icing conditions and the removal of ice on the affected airplane surface does not result in an unacceptable degradation in airplane performance and handling characteristics. The data should be recorded in the flight test report.

(4) Fluid Anti-Ice/Deice Systems. Flight testing should include evaluation of fluid flow paths to confirm that adequate and uniform fluid distribution over the protected surfaces is achieved. Fluid flow paths should be determined when the fluid is mixed with impinging water during system operation. In cold temperatures, fluid flow paths determined without the impinging water may result in the anti/deice fluid freezing on the surface to be protected. A means of indicating fluid flow rates, fluid quantity remaining, etc., should be evaluated to determine that the indicators are plainly visible to the pilot and that the indications provided can be effectively read. A shutoff valve should be provided in systems using flammable fluids. The fluid anti-ice/deice systems may be used to protect propellers and windshields as well as leading edges of airfoils. The fluid for windshield fluid anti-ice systems should be tested to demonstrate that it does not become opaque at low temperatures. The Airplane Flight Manual should include information so the flightcrew will know how long it will take to deplete the amount of fluid remaining in the reservoir.

e. Performance and Handling Qualities. Airplane performance and handling qualities are degraded by ice accumulations in various ways depending upon the type, shape, size, and location of these accumulations. Because of these variations in degradation, it is difficult to establish a standard method of demonstrating satisfactory performance with such degradations. However, certain minimum tests should be used to demonstrate that the airplane does not have unsafe features or characteristics that prevent it from operating safely in the part 25, Appendix C, icing envelope. A minimum set of flight tests for determining the effects of ice accretions on airplane performance and handling characteristics is presented in AC 25-7A, “Flight Test Guide for Certification of Transport Category Airplanes.”

f. Pneumatic Deicer Boots. Many AFM's specify a minimum ice accumulation thickness prior to activation of the deicer boot system. This practice originates from the belief that a bridge of ice could form if the boots are operated prematurely. Although the ice may not shed completely with one cycle of the boots, this residual ice will usually be removed during subsequent boot cycles and does not act as a foundation for a bridge of ice to form. The AFM procedure for boot operation should be to operate the boots at the first sign of ice and not wait for a specific amount of ice to accumulate.

Note: Activation of the deicing boots typically results in one cycle of inflation and deflation of all boots, but not necessarily at the same time. Some systems are designed such that a complete cycle of the boots does not occur (i.e., some boots are not inflated) if the ice protection system is “selected off” before the cycle is complete. For these systems the AFM should include information to warn the flightcrew to select the ice protection system on for at least one complete cycle of the deicing boots. This note is equally applicable to other deicing systems that similarly do not activate all portions of the deicing systems simultaneously.

g. Emergency and Abnormal Operating Conditions. Flight tests should be conducted to demonstrate continued safe flight and landing, using appropriate AFM abnormal and/or emergency operating procedures, following failures in the ice protection system. These demonstrations should be conducted with anticipated residual ice accumulation on normally protected surfaces.

h. Ice Detector System (Primary and Advisory). Ice detector systems either directly detect the presence of ice on the airplane surface or detect that the airplane is in icing conditions. In the latter case, flight testing is typically performed to correlate the detected icing conditions and the presence of ice on the airplane. The primary system is the prime means used to determine when the ice protection system should be activated. The activation of the ice protection system may be automatically or manually activated. An advisory system is not the prime means used to determine if the ice protection system should be activated. Typically, when there is an advisory system installed on an airplane, the flightcrew is the primary means for determining when the ice protection system should be activated.

7. PERFORM INTENDED FUNCTION IN ICING. All systems and components of the basic airplane should continue to function as intended when operating in an icing environment including, for example:

a. Engines and Equipment. Engines and equipment (such as generators and alternators operating under maximum ice protection load) should be monitored during icing tests for adequate cooling (§ 25.1041) and be found acceptable for this operation (§§ 25.1093 and 25.1301).

b. Engine Alternate Induction Air Sources. Engine alternate induction air sources should remain functional in an icing environment.

c. Fuel System Venting. Fuel system venting should not be adversely affected by ice accumulation.

d. Landing Gear. A retractable landing gear should operate as intended following an icing encounter. Gear retraction should not result in an unsafe indication because of ice accretion.

e. Stall Warning. Ice could form on stall warning and angle-of-attack sensors if these devices are not protected. Therefore, the sensors' functions should be evaluated for operation in the icing conditions of Appendix C. Adequate stall warning (aerodynamic or artificial) should be provided with ice accumulations on the airplane. Ice accumulations that should be considered are those on unprotected surfaces, those that occur prior to the initial activation of the ice protection system, those that occur between the ice protection activation cycles, and those that remain after one cycle of the ice protection system. The activation points of artificial stall warning and stall identification systems, if installed, may need to be reset for operations in icing conditions to provide adequate stall warning margins and to prevent inadvertent stalling or loss of control, respectively.

f. Ice Detection Cues. Ice detection cues that the pilot relies on for timely operation of ice protection equipment should be evaluated in anticipated flight attitudes.

g. Primary and Secondary Flight Control Surfaces. Primary and secondary flight control surfaces should remain operational after exposure to icing conditions. Demonstrate that aerodynamic balance surfaces are not subject to icing throughout the airplane's operating envelope (weight, center of gravity, and speed) or that any ice accumulation on these surfaces does not interfere with or limit actuation of the control for these surfaces, including retraction of flaps for a safe go around from the landing configuration.

h. Ram Air Turbine. The ram air turbine should remain operational. It does not need to be tested in natural icing conditions if tested in the icing wind tunnel.

i. Pilot Compartment View. In support of compliance with § 25.773, Pilot compartment view, any obstruction of the pilots' view due to ice accumulation should be noted.

8. ICE DETECTION LIGHT(S). Unless operations at night in known or forecast icing conditions are prohibited by an operating limitation, § 25.1403 requires that a means be provided for illuminating or otherwise determining the formation of ice on the parts of the wings that are critical from the standpoint of ice accumulations.

a. If the wings cannot be observed by the flightcrew, one acceptable means of compliance with this regulation would be the installation of an ice evidence probe located in a position where the flightcrew can observe the ice accumulation. Formation of ice on the device should be shown to precede or occur simultaneously with the formation of ice on the wings. Consideration should be given to the need for illumination of the ice evidence probe.

b. Ice detection lights should be evaluated both in and out of clouds during night flight to determine that adequate illumination of the component of interest is available without excessive glare, reflections, or other distractions to the flightcrew. These tests may be conveniently accomplished both in and out of clouds during the airplane certification flight tests. Typically, airplane-mounted illumination has been used as a means of compliance with this regulation. Use of a hand-held flashlight has not been considered acceptable due to the associated workload. The appropriate manual should identify the ice characteristics the flightcrew is expected to observe and the flightcrew action associated with the observation.

9. ICE-CONTAMINATED TAILPLANE STALL (ICTS). This phenomenon occurs due to airflow separation on the lower surface of the tailplane. This can occur if the angle-of-attack of the horizontal tailplane exceeds the stall angle-of-attack, which can be reduced by even small quantities of ice on the tailplane leading edge. The increase in tailplane angle-of-attack can result from airplane configuration (e.g., increased flap extension increasing the downwash angle or trim required for the center-of-gravity position) and flight conditions (e.g., a high approach speed resulting in an increased flap downwash angle, gusts, maneuvering, or changes to engine power setting). ICTS is characterized by a reduction or loss of pitch control or stability while operating in, or after recently departing from, icing conditions. For airplanes with unpowered longitudinal control systems, the pressure differential between the upper and lower surfaces of the stalled tailplane may result in a high elevator hinge moment, forcing the elevator trailing edge down. This elevator hinge moment reversal can be of sufficient magnitude to draw the control column forward with a level of force that is beyond the combined efforts of the pilot and copilot to overcome. On some airplanes, ICTS has been caused by a lateral flow component coming off of the vertical stabilizer, as may occur in sideslip conditions or due to a gust with a lateral component. Aerodynamic effects of reduced tailplane lift should be considered for all airplanes, including those with powered controls. An evaluation should be made to determine if this unsafe flight condition is likely to occur. Airplanes susceptible to this phenomenon are those having a near zero or negative tailplane stall margin with tailplane icing contamination. An acceptable flight test procedure for determining susceptibility to ICTS is presented in AC 25-7A.

10. CAUTION INFORMATION. Section 25.1419(c) requires that caution information be provided to alert the flightcrew when the ice protection system is not functioning normally. Caution information should be provided if the failure condition of the ice protection system can result in a hazardous airplane condition. It should be assumed that icing conditions exist during the failure event. The decision to provide the caution information should not be based on the numerical probability of the failure event (i.e., even if a numerical probability analysis indicates the system failure is improbable or extremely improbable, the caution information should be provided if the failure could result in a hazardous condition).

a. The placement of the sensor(s) used to identify a failure condition should be evaluated to ensure that the sensors are properly located to obtain accurate data on the failure of the ice protection system.

b. The applicant should submit data to substantiate that the indication system does not give a false indication that the system is functioning normally. For example, if a pneumatic deicing system (boots) requires a specific minimum pressure and pressure rise rate to adequately shed ice, then caution information should be provided if the minimum pressure and pressure rise rate are not attained. If this caution information is not provided, the flightcrew may erroneously believe that the boots are operating normally when, in fact, the boots might not be inflating with sufficient pressure or rate of inflation to adequately shed the ice. The need for caution information should also be considered for the case of ice forming in the pneumatic system that can result in low pneumatic boot pressures or an inadequate pressure rise rate.

11. ICE SHEDDING. Ice shedding from forward airplane structures may damage or erode engine or powerplant components as well as lifting, stabilizing, and flight control surface leading edges. Fan and compressor blades, impeller vanes, inlet screens and ducts, as well as propellers, are examples of powerplant components subject to damage from shedding ice. For fuselage-mounted turbojet engines (and pusher propellers that are very close to the fuselage and well aft of the airplane's nose), ice shedding from the forward fuselage and from the wings may cause significant damage. Ice shedding from components, including antennas, of the airplane should cause no more than cosmetic damage to other parts of the airplane, including aft-mounted engines and propellers (compliance with § 25.1093). Consideration should also be given to airplane damage that can occur due to ice shedding from the propellers.

Control surfaces such as elevators, ailerons, flaps, and spoilers are also subject to damage, especially those constructed of thin metallic, nonmetallic, or composite materials. Trajectory and impingement analyses may not adequately predict such damage. Unpredictable ice shedding paths from forward areas such as radomes and forward wings (canards) have been found to negate the results of these analyses. For this reason, a damage analysis should consider that the most critical ice shapes will shed and impact the areas of concern.

12. AIRPLANE FLIGHT MANUAL (AFM). The AFM should provide the pilot with the information needed to operate the ice protection system, including the following:

a. Operating Limitations Section.

(1) The minimum airspeed that should be maintained for each normal airplane configuration whenever ice exists on the critical surfaces.

(2) Instructions to activate the engine anti-ice system if Instrument Meteorological Conditions (IMC) are encountered at an altitude near or above the freezing level.

(3) Landing weight limitations should be presented for flight in icing that reflect any effects on lift, drag, thrust, and operating speeds related to operating in icing conditions. These weight limitations may be presented in the Performance Information Section of the AFM and included as limitations by specific reference in the Limitations Section of the AFM.

(4) Limitations on operating time for ice protection equipment, if these limitations are based on fluid anti-ice/deice systems capacities and flow rates.

(5) Speed limitations (if any) and minimum temperature for deicing boot operation for airplanes equipped with boots.

(6) Environmental limitations for equipment operations as applicable (e.g., minimum temperature for boot operation or maximum altitude for boot operation).

(7) Minimum engine speed if the airframe ice protection system does not function properly below this speed.

(8) A list of required placards.

(9) For airplanes with unpowered roll controls and pneumatic deicing boots, a warning should be provided for severe icing that may result from environmental conditions outside the icing envelope established as the basis of the approval defined in Appendix C (reference the AFM information in paragraphs 12d(3) and (4)).

b. Operating Procedures Section.

(1) Section 25.1585(a)(6) requires that the pilot be provided with recommended procedures for the use of ice protection equipment. This should include any preflight action necessary to minimize the potential of enroute emergencies associated with the ice protection system. The system components should be described with sufficient clarity and depth that the pilot can understand their function. Unless flightcrew actions are accepted as normal airmanship, the appropriate procedures should be included in the FAA-approved AFM, AFM revision, or AFM supplement. These procedures should include proper pilot response to cockpit warnings, a means to diagnose system failures, and the use of the system(s) in a safe manner.

(2) Procedures should be provided to optimize airplane operation during penetration of icing conditions, including climb, holding, and approach configurations and speeds. The AFM should define when the ice protection equipment should be activated.

(3) Emergency or abnormal procedures, including procedures to be followed when ice protection systems fail and/or warning or monitor alerts occur, should be provided.

(4) For fluid anti-ice/deice systems, information and method(s) for determining the remaining flight operation time should be provided.

(5) For airplanes that cannot supply adequate electrical power for all systems at low engine speeds, load-shedding instructions should be provided to the pilot for approach and landing in icing conditions.

c. Performance Information Section. Data should be provided so that the maximum landing weight, as limited by approach and landing climb performance (§§ 25.121(d) and 25.119 respectively) can be determined in icing conditions. These data should include the effect of drag due to residual ice on protected and unprotected surfaces, the power extraction associated with ice protection system operation, and any changes in operating speeds due to icing. The effect on landing distance due to revised approach speeds, and/or landing configurations, should be shown.

d. Airworthiness Directives for Severe Icing Conditions.

(1) In October 1994, an accident involving a transport category airplane occurred in which severe icing conditions were reported in the area. During extensive testing the accident profile was replicated by ice shapes developed from testing in an icing cloud having droplets in the size range of freezing drizzle at a temperature near freezing. This condition created a ridge of ice aft of the deicing boots and forward of the ailerons, which resulted in uncommanded motion of the ailerons and rapid roll of the aircraft.

(2) Following this accident the FAA determined that flightcrews are not currently provided with the information necessary to determine when the airplane is operating in icing

conditions that have been shown to be unsafe and for which the airplane is not certificated; or what action to take when such conditions are encountered. Therefore, the FAA determined that flightcrews must be provided with such information, and must be made aware of certain visual cues that may indicate when the airplane is operating in atmospheric conditions that are outside the part 25, Appendix C icing envelope.

(3) The FAA is particularly concerned with airplanes that are equipped with pneumatic deicing boots and non-powered roll control systems, since non-powered roll flight controls do not have the physical advantage of hydraulic or electrical power to assist the pilot in overcoming the large control forces that may exist from differential pressure resulting from flow separation over the roll control surfaces. The FAA issued a series of Airworthiness Directives (AD's) in April 1996 and February 1998 on airplanes equipped with pneumatic deicing boots and non-powered roll control systems. The AD's require revising the Airplane Flight Manual (AFM) to provide the flight crew with recognition cues for, and procedures for exiting from, severe icing conditions, and to limit or prohibit the use of various flight control devices. Other similarly equipped aircraft should also include this information in the AFM.

(4) The limitations and procedures specified in Airworthiness Directive (AD) 96-09-25 are an acceptable means of providing this information. These limitations and procedures include, but are not limited to, the following:

(a) Visual cues that the airplane is in severe icing conditions;

(b) Prohibition on the use of the autopilot when the visual cues are observed;

(c) All icing detection lights operative prior to flight into icing conditions at night;

(d) Immediate exiting of the severe icing conditions; and

(e) If the flaps are extended, do not retract them until the airframe is clear of ice.

Note: The retraction of the flaps is contingent upon the existence of a means to determine if the airframe is clear of ice.